RADIATION HAZARDS

by

Helen B. Shaffer

	Page
CONCERN OVER EFFECTS OF RADIATION ON MAN	103
Research on Radiation-Free Hydrogen Fusion	103
Attempts to Curtail Exposure to Radiation	103
Efforts to Balance Risks Against Benefits	104
Immediate and Delayed Effects of Radiation	106
Dangers to Human Race in Genetic Mutations	107
GROWTH OF RADIATION IN HUMAN ENVIRONMENT	108
Major New Sources of Man-Made Radiation	109
Bomb Testing, Fallout, and "Clean" Bombs	110
Power Production and Radioactive Materials	112
Radiation From X-rays and From Isotopes	113
PROTECTION OF PUBLIC FROM RADIATION RISKS	114
Safety Record of U.S. Atomic Energy Plants	115
Problems in Disposal of Radioactive Wastes	116
Controls to Reduce the Hazards of Radiation	117

Feb. 12
1958

RADIATION HAZARDS

DISCLOSURE by British and American atomic energy authorities on Jan. 24 that significant progress had been made toward controlling the power produced in the process of hydrogen fusion kindled hopes for eventual elimination of one of the major hazards of the atomic age. The process of uranium fission, now used to generate atomic power, produces radioactive end-products and raises formidable problems of waste disposal. The fusion process involves no such hazards and it promises to make available virtually unlimited quantities of power at competitive costs.

The United States, Great Britain, and Soviet Russia are pursuing intensive research on the fusion process. However, a generation may pass before it can be developed to the point of practical and widespread application. Henry DeWolf Smyth, formerly a member of the U.S. Atomic Energy Commission, said on Jan. 30 that "What has been achieved so far is merely the first stage in a long, long period of study."

Facilities to produce power through splitting the atom are therefore likely to be undergoing expansion for many years to come. As a result, unprecedented amounts of harmful radioactive substances may be released into the atmosphere. Many public health authorities believe that growth in the use of atomic energy and of the products of atomic fission holds a greater threat to the well-being of the population at large than does the testing of atomic weapons.

Decisions of major importance are being taken in the field of radiation control at a time when data on the effects of radiation on human health are inconclusive and when leading scientists differ on the meaning of the evidence at hand. For this reason, current regulations aim to keep radiation exposure as low as can be done without impeding atomic research or use of radioactive materials in helpful

ways. Two recent rulings illustrate the extreme caution currently governing official policy: A cutback in use of X-rays for public health surveys, and a lowering of the permissible radiation dosage for atomic workers.

The U.S. Public Health Service recommended last November that mass chest X-ray surveys—a program of tuberculosis detection originally intended to cover four-fifths of the population—be conducted only in areas where there is known to be a high incidence of tuberculosis. The reasons given were (1) a decline in the incidence of the disease[1] and (2) concern over the effects of accumulations of low-level radiation, particularly in the early years of life.

The Atomic Energy Commission on Dec. 10 lowered by two-thirds the levels of radiation exposure permissible for atomic workers and for residents near atomic facilities. The new levels, which reportedly cannot be further lowered without seriously curtailing beneficial use of atomic energy, are designed in particular to protect atomic workers during their reproductive years. The dosage will be limited in future to an average of five rems[2] a year up to age 30 and to no more than 15 rems in any one year; previously, young workers were permitted to receive up to 15 rems every year.

Although no ill effects had been observed under the earlier rules, the authorities felt it prudent to reduce the dosage to the minimum. Like the Public Health rule on X-rays, the new A.E.C. standard is based on the principle that exposure should be allowed only when absolutely necessary to serve some useful purpose. "Even when a useful purpose is served . . . all radiation exposures should be kept at a minimum, especially to the germ cells." [3]

Efforts to Balance Risks Against Benefits

Much of the disagreement among scientists about the dangers of radiation reflects differences in assessment of the balance between risks of injury and possibilities of benefit. Public health authorities, for example, try to avoid frightening patients into refusing to be X-rayed when the good to be achieved may far outweigh any damage that could be suffered.

---

[1] There are an estimated 250,000 cases of active tuberculosis in the United States. The number has declined by nearly 30 per cent in the past five years. Some areas are now virtually free of the disease.

[2] Rem, standing for "Roentgen equivalent man," is a unit for measuring the biological damage caused by radiation.

[3] Charles L. Dunham, director of Division of Biology and Medicine, A.E.C., before Academy of Medicine of Cincinnati, Feb. 27, 1957.

Although scientists concur that radiation presents serious hazards, many of them feel that the risk of injury is slight if adequate safety precautions are taken. The "lethal" properties of the internal combustion engine, "cause" of 39,000 traffic deaths a year in the United States, are often cited to put radiation hazards in perspective. The public is advised to accept calmly the risks of added radiation, as it has accepted the hazards of past technological advances, as the price of the benefits conferred by atomic energy. The difficulty is that the extent of the risks has not been fully ascertained.

Surveys of scientific literature and opinion have all come to the conclusion that more knowledge is needed to assure adequate safeguards. The National Academy of Sciences said in a section of its 1956 report dealing with genetics that it was hard to strike "a balance of opposed risks" because "the risk on neither side is completely visible." It noted in particular that "Scientists cannot say with exact precision just what biological risks are involved in various levels and sorts of radiation exposure." [4] The British Medical Research Council reported about the same time that "many large and serious gaps in our knowledge of the medical and biological effects of ionizing radiation" must be filled "if the potentialities for good are to be exploited with confidence and safety." [5]

The congressional Joint Committee on Atomic Energy, summarizing testimony of expert witnesses at hearings last spring, observed that "The differences of opinion . . . hardest to reconcile appear to be those concerning the biological effects of radiation." But all the experts agreed that there was "a limit to the amount of radioactivity . . . that man can tolerate in his environment." [6]

In a review of radiation's effects on heredity, the World Health Organization reported recently that "The well-being of descendants of the present generation is threatened by developments in the use of nuclear energy and of sources of radiation." It added, however, that "Both of these developments are inevitable and should contribute much to man's social and cultural development." "Only in the light

[4] National Academy of Sciences-National Research Council, *The Biological Effects of Atomic Radiation* (1956), pp. 5-6.

[5] Medical Research Council, *The Hazards to Man of Nuclear and Allied Radiations* (June 1956).

[6] Joint Committee on Atomic Energy, *Summary-Analysis of Hearings May 27-29 and June 3-7, 1957* (August 1957), p. 3.

of more knowledge can decisions be taken to define more accurately the maximum amount of exposure which may be accepted . . . without risk of serious harm." [7]

Immediate and Delayed Effects of Radiation

Modern medicine has had considerable experience with the damaging effects on human health of overdoses of radiation; it has had somewhat more limited opportunity to study the effects of long-time exposure to many small doses of radiation. The earliest data had to do with the results of careless handling of X-ray machines and radioactive materials. Medical records dating back 50 years contain accounts of stubborn burns and skin lesions, of loss of hair and other disturbances obviously caused by radiation.

The harmful effects of an accumulation of radioactive substances within the body were not recognized as promptly. Doctors freely injected radium for numerous ailments, from arthritis to sterility, as late as the 1930s. Yet there were already cases in which radiological personnel had developed skin cancer or suffered bone-marrow damage years after their first exposure to radiation. Even today some statistics point to a high incidence of diseases which can be induced by radiation, such as leukemia, and to a shortening of the life span among doctors and technicians often exposed to X-rays.[8]

Injury to radiological personnel has been caused by external exposure to the penetrating X-ray. Two other occupational groups gave early insight into the nature of delayed radiation injury from other sources. German miners working radioactive ore attracted medical interest because approximately one-half of them died of lung cancer; they were found to have inhaled a radioactive gas, radon, and minute amounts of radioactive solids in dust particles. A number of American women employed to paint watch dials with radium during World War I began, several years later, to show serious symptoms of such diseases as bone tumor and anemia. They had "tipped" their brushes with their lips and thus taken into their systems long-lived radioactive substances which tend to lodge in the bones. Many of the women died of radiation-induced illness.

New knowledge about the delayed effects of radiation has

[7] World Health Organization, *Effect of Radiation on Human Heredity* (1957), p. 11.

[8] The National Academy of Sciences cited a study showing average age of radiologists at death as 60, compared with 65½ for doctors making little use of X-ray, but the College of Radiology challenged the figures.

come from follow-up studies of the atom-bombed survivors of Hiroshima and Nagasaki and from studies of individuals in the path of radioactive fallout from bomb tests. The data, supplemented by laboratory studies, indicate that a host of ailments may—or may not—show up years after exposure and after healing of an initial lesion.

The British Medical Research Council said in 1956: "The severity of radiation injury in any particular instance is determined by the interplay of several factors: the type and dose of radiation received, the duration of the period of exposure, the extent and part of the body which has been irradiated, and also the age of the person exposed." Serious symptoms appeared in the radium dial workers from one to 30 years after exposure. The average elapsed time in the case of the German miners was 17 years. The recent death from a liver ailment of a 52-year-old Hiroshima man was the second in 1958 attributed to the delayed effects of the 1945 bombing.

Dangers to Human Race in Genetic Mutations

More alarming than injury to the individual, and far more difficult to assess and control, is the danger that radiation may result in lasting harm to the genetic vigor of the human race. The National Academy of Sciences has said:

> The basic fact is . . . that radiations produce mutations and that mutations are in general harmful. It is difficult, at the present state of knowledge of genetics, to estimate just how much of what kind of harm will appear in each future generation after mutant genes are induced by radiations. Different geneticists prefer differing ways of describing this situation: But they all come out with the unanimous conclusion that the potential danger is great.[9]

Mutations affect, usually in an unfavorable way, the hereditary characteristics passed on from parents to children. The genetic stream of life normally carries a certain number of spontaneous mutations which tend to disappear because individuals carrying the resultant defects are less likely to survive or reproduce. A large increase in man-made radiation upsets the natural balance between spontaneous production and disappearance of mutant genes. It causes a larger percentage of the population to carry hereditary defects which may be passed on for many generations. The defects may be minor or severe. The British report on radiation hazards expressed particular concern

[9] National Academy of Sciences—National Research Council, *op. cit.*, p. 29.

over the potential increase of congenital mental illness and low intelligence.

The National Academy of Sciences estimated that if 10,000 individuals received large doses of radiation (about 200 roentgens), "then perhaps 100 of [their] children . . . would be substantially handicapped." If the entire population of the United States received a small extra dose of radiation (about one roentgen), there was "good reason to think that, among 100 million children born to these exposed parents, there would be several thousand who would be definitely handicapped because of the mutant genes due to radiation."

From the standpoint of heredity there is no safe dose of radiation. Any radiation is genetically undesirable. The unanswered question is how much additional radiation in the population at large will cause a given level of mutation increase, and with what effect on future generations. The important factor is the total dose received by the germ cells. Whether the amount is received in a single heavy dose or many small doses, over whatever period of time, makes no difference because the effect is cumulative. It is for this reason that authorities give particular attention to the amount of radiation received by individuals up to and including their reproductive years.

Growth of Radiation in Human Environment

THE RADIATION which gives so much concern today is a wave or stream of highly concentrated energy emitted as the result of an unstable condition of atoms. The most common forms include (1) X-rays, which are sent out in waves when fast-moving electrons strike a metal target; (2) gamma rays [electro-magnetic radiations from atomic nuclei] and minute atomic particles [electrons, protons, neutrons, and alpha particles], which are thrown out when the atom is split; and (3) particles or rays emitted spontaneously by radioactive [that is, atomically unstable or disintegrating] substances such as radium.

The rays and particles have different powers of penetration. Gamma rays may pass completely through a human

body and cause general illness rather than localized injury. Alpha particles have little penetrating power, while beta particles can penetrate soft tissue a minute distance; the injuries they cause externally may be superficial, but when these particles are introduced into the body, the persistent irradiation may be very destructive. The damaging effects of X-rays vary greatly, depending on the electrical energy used in their discharge, so that the biological effects may range from that of the gamma ray to that of the alpha particle.

These types of radiation are usually known as ionizing radiation because they leave a number of electrically charged atoms and molecules, called ions, in their tracks as they pass through tissues. The ions cause injurious physical and chemical changes in tissue. Some have a particular affinity for certain parts of the body, especially the bones, the blood-forming tissues, tumors and all growth tissue.

Major New Sources of Man-Made Radiation

Until the late years of the last century, nature was the only source of ionizing radiation. Amounts so received, chiefly cosmic radiation and rays from radioactive elements in the earth's crust, are small and variable, depending on geography and altitude. They would give little concern if they did not have to be counted, along with newer forms of radiation, in the total amount to which man is exposed.

Man-made radiation came into the picture with Roentgen's discovery of X-rays in 1895 and Henri Becquerel's discovery of radioactivity in uranium salts a year later. The discoveries led to extensive use of X-ray machines and radioactive substances in medical practice and in research and industry.

A new radiation factor was added in 1934 when Frederic Joliot and his wife, Irene Curie, devised a method of producing radioactive elements artificially. Later, the invention of the cyclotron made possible quantity production of radioactive isotopes which have a multitude of beneficial uses. The first splitting of the uranium atom in December 1938 by two German chemists, Hahn and Strassman, led the way to developments which produced the first atomic bomb. Production of atomic power and fission products for civilian uses followed World War II.

Thus the sources of man-made radiation have been multiplying. U.S. Surgeon General Leroy S. Burney testified before the Joint Committee on Atomic Energy on June 7: "The fact that exposure from other sources is on the increase makes it necessary to re-examine and reassess the use of radiation for research and for healing purposes. Exposure levels from a given source which might have been acceptable in the past may now—or in the future—become hazardous when added to the exposure from other sources."

Another officer of the U.S. Public Health Service recently cited the following sources of radiation to which modern man is exposed:

Radiation from nature—about nine roentgens over a 70-year life span.

Radiation from weapons tests—"probably very low" so far but an unknown future hazard.

Medical diagnosis and treatment by radiation—the major source for most persons.

Use of radioisotopes, radium, cobalt 60, and X-rays for radiographic purposes—relatively small numbers of persons exposed.

Radioactive emanations from nuclear reactor plants—"should be relatively insignificant" because of safety measures.

Radioactivity escaping from chemical processing plants—"at present time . . . not community hazards."

Transportation of radioactive material—fully regulated for safety.

"Inherent hazards from major accidents."[10]

Of all the sources of radiation, none has caused more furor than the fallout resulting from detonation of atomic test weapons.

Bomb Testing, Fallout, and "Clean" Bombs

Questions of national defense and international relations and the moral questions involved in testing atomic weapons have made it difficult to obtain objective assessments of the hazards raised by radiation from this source. Most studies indicate that the actual amounts of radiation so far given off by weapons tests present slight hazard to the present generation of mankind, but that the potential genetic effects may be serious.

Popular interest in the fallout debate became particularly keen after the United States detonated the first hydro-

[10] James G. Terrill, Jr., chief of radiological health program, U.S. Public Health Service, in speech to A.F.L.-C.I.O. conference on radiation, Feb. 27, 1957.

gen test bomb in the Pacific in March 1954 and a soft radioactive ash fell on some of the test personnel, a number of Marshall Islanders, and 23 Japanese fishermen.[11] The widely publicized plight of the injured fishermen, and the ensuing tension between the United States and Japan, not only aroused world-wide interest in the question but also greatly enhanced the political overtones of the scientific debate. Since that time, there have been a number of official inquiries into the fallout problem,[12] but the findings have not put an end to the debate. On the basis of testimony taken at its hearings last spring, the Joint Committee on Atomic Energy cited the following general conclusions in an August report:

> 1. All nuclear explosions produce some radioactive materials.
>
> 2. Fallout is not uniformly distributed in the atmosphere.
>
> 3. Man's exposure to fallout is small so far, compared with his exposure to other sources of radiation, but experts are not agreed on how this fact should be interpreted.
>
> 4. Pending a resolution of differences [on the biological effects of radiation] it would appear . . . that the consequences of further testing over the next several generations at the level of testing of the past five years could constitute a hazard to the world's population.

The strontium-90 in radioactive fallout is the source of greatest concern because that substance settles in the bones, where it may cause cancer, and because every addition in the human body is cumulative. Results of a five-year study of human bone samples, gathered from 30 places around the globe, were reported on Feb. 6 by three Columbia University scientists working under an A.E.C. grant. They found that strontium-90 concentration in the human body rose 33 per cent in the year ended June 30, 1957. Although the concentration then amounted to only 1/150th of the maximum permissible under present standards, the level at the current rate of increase would rise by the year 2,000 to 1/5th of the maximum. The study showed that children under four had a concentration ten times that of adults, and women on the average had a 15 per cent higher concentration than men.

Scientists who regard fallout as a major hazard have gone to extraordinary lengths to publicize their views.

---

[11] The hydrogen (fusion) bomb had to be triggered by an atomic (fission) device.

[12] The Atomic Energy Commission reported last spring that it had devoted a total of 1,006 "scientific man-years" to studies and research projects on fallout and allied problems.

Albert Schweitzer, renowned missionary-scientist, attracted world attention last April by issuing a "Declaration of Conscience" in which he said: "We are committing a folly in thoughtlessness." Dr. Linus Pauling, Nobel prize-winning biochemist, has taken the lead in promoting anti-test petitions; the most recent, presented to the United Nations on Jan. 13, bore the signatures of 9,000 scientists from 44 countries. The Federation of American Scientists has spoken up repeatedly against the tests. Among nations, Japan has been the foremost complainant; it petitioned the U.N. Disarmament Commission in London last April to seek an end to bomb tests.

Despite protests, there is little likelihood that nuclear weapons testing will be dropped in the near future. However, hope has been raised that a "clean" bomb—that is, one causing a minimum of radioactive fallout—can be developed. President Eisenhower and British Prime Minister Macmillan stated on Mar. 24, 1957, following conversations in Bermuda: "We declare our intention to continue to conduct nuclear tests only in such manner as will keep world radiation from rising to more than a small fraction of the levels that might be hazardous. We look to the Soviet Union to exercise a similar restraint."

Three leading nuclear scientists (Edward Teller, Ernest O. Lawrence, and Mark M. Mills) reported to the President last June 24 that radioactive fallout from a hydrogen bomb explosion had already been reduced by 95 per cent. They were confident of the eventual development of a tactical bomb which would have high explosiveness on a military target but would produce only "essentially negligible" amounts of fallout. Teller has argued that "a ban on tests would stop our development before we could make our explosives . . . more humane, and before we could put them to a constructive use." [13]

Power Production and Radioactive Materials

Even if no bombs were detonated, the radiation level would be appreciably increased by expanding civilian use of atomic energy and fission by-products. Dr. John C. Bugher, public health director for the Rockefeller Foundation, has warned that "Even a modest nuclear power program will bring into existence vastly greater quantities of radioactive materials than are produced in the development

[13] Edward Teller, "Alternatives for Security," *Foreign Affairs*, January 1958, p. 205.

of nuclear weapons." [14] Sanitary engineers who attended a nuclear conference sponsored by 24 scientific and engineering societies in Philadelphia last March cited two special dangers attending growth of the atomic power industry: (1) Radioactive wastes in streams and (2) concentration in plant life of radioactivity which may be passed on to man through food.

The Atomic Energy Act of 1954 authorized private American companies to acquire nuclear fuels and build their own nuclear reactors.[15] The first reactor in the United States to produce electric power for civilian use began operating in February 1957 at Lemont, Ill. The first full-scale civilian power plant, capable eventually of meeting the electricity needs of a residential community of 250,000 population, went into operation at Shippingport, Pa., on Dec. 2, 1957.[16] Eight experimental civilian power reactors were in operation during 1957, and four more full-scale reactors were under construction. These are chiefly pilot plants to serve as models for large, permanent installations. Nuclear power is being developed also as a propellant in transportation. Nuclear-powered submarines are already a reality, the keel for the world's first atomic-powered aircraft carrier was laid at Newport News, Va., on Feb. 4, and the first atomic-powered merchant vessel is scheduled for completion in 1960.

Radiation from X-rays and from Isotopes

Use of radiation for diagnostic or therapeutic purposes in medical practice is still the source of most of the radiation received by a majority of individuals. An estimated 54 million diagnostic X-ray examinations or fluoroscopies were performed in hospitals and doctors' offices last year, while dentists exposed more than 100 million X-ray films in patients' mouths.[17] These estimates do not include exposures to radiation from use of deep X-ray and radioactive substances in treatment of diseases, notably cancer.

[14] Address, National Citizens Committee for the World Health Organization, Atlantic City, Nov. 14, 1956.

[15] A nuclear reactor is a device for controlled production of the atom-splitting reaction in fissionable materials. The function of reactors is to produce power, heat, and various irradiated products useful in industry, research, and medicine. According to the Atomic Energy Commission, 149 nuclear reactors were in operation or had been in operation (some had been dismantled) by the end of last year, 89 were under construction, and 67 were in the planning stage. The totals included 23 power reactors in operation, 46 under construction, and 19 planned. Many of the reactors were experimental, for military use, or for export.

[16] The only other comparable atomic power plant has been in operation at Calder Hall, England, since 1956.

[17] Albert Q. Maisel, "What's the Truth About Danger in X-Rays?" *Reader's Digest*, February 1958, p. 26.

Atomic developments have given medicine, industry, and agriculture new and useful tools in the form of artificially produced radioactive products. Virtually every medical specialty has found some use for radioisotopes. The A.E.C. during 1957 licensed 1,900 doctors and medical institutions to use radioisotopes and issued 1,600 licenses for use of radioisotopes in industry. Industrial uses have been found for radioisotopes in atomic batteries, which convert atomic radiation into electric current; in heatless vulcanization of automobile tires; and in thickness gauges and other devices. The possibilities in agriculture include employment of radioisotopes in connection with pest control, vegetable storage, development of improved animal and plant strains, improvement of fertilizers, and studies of animal nutrition and of animal and plant diseases.

Radiation in tiny amounts enters the atmosphere from familiar objects in daily use. Among them are watches and clocks with luminous dials and the cathode-ray tubes in television sets (whose X-rays are absorbed by walls of the tubes and by protective screens). Several thousand X-ray shoe-fitting devices are still being used in stores despite advice to the contrary by public health authorities.

Protection of Public from Radiation Risks

FEAR that mankind may suffer grave damage from use of atomic energy for peaceful purposes, no less than from its use for military purposes, has been growing with the prospect of rapid expansion of atomic power installations and other civilian applications. A special source of apprehension is the possibility of "leakage" of radioactive materials or wastes to contaminate the air, the water supply, and the food of communities near atomic plants. The chance of a major accident, such as an explosion or a "runaway" nuclear reaction, has brought visions of a catastrophe of mammoth proportions. The approach of atom-powered locomotives and airplanes as well as ships has added to such fears.[18]

[18] Roger Revelle of the Scripps Institute of Oceanography told the Joint Committee on Atomic Energy, May 27, 1957, that "If and when an appreciable part of the world's merchant fleet is powered by nuclear reactors, serious hazards may arise in confined waters from collisions in which the reactor is damaged and the fuel elements with their contained fission products are lost in the water."

A World Health Organization study group reported last November that it had found considerable mental distress from "irrational fears" about atomic energy. "Perhaps the most terrifying and characteristic aspect of atomic energy for the popular imagination was that its tremendous power might get out of control."

Safety Record of U.S. Atomic Energy Plants

Actually, safety devices and regulations have kept pace so far with development of atomic energy facilities. In this respect the development is unusual, for other technological advances often have introduced hazards which persisted until safeguards finally were set up to protect the public. Liberal use of the X-ray machine for sundry medical and cosmetic purposes is a case in point.

The Atomic Energy Commission has asserted that since the first nuclear reactor in the United States was successfully put into operation a decade and a half ago, "no member of the public is known to have suffered an overexposure to radiation as a result of living near atomic energy production or laboratory centers." The agency considers its safety record "without parallel in industrial history," despite the peculiar hazards of working with large quantities of a deadly material which cannot be apprehended by any of the human senses unaided.

Built-in safety devices, "administrative control" over reactor operations, painstaking industrial "housekeeping," and strict discipline in enforcing safety rules among employees are given credit for the good safety record. Massive shielding around concentrations of intense radiation, limitation of work periods in radioactive areas, use of metering devices, and the wearing of special clothing are among standard safety precautions. The reactor's control system includes a mechanism which shuts off the nuclear reaction in case of abnormal developments.

There have been only two deaths from radiation poisoning among atomic workers in this country as a result of atomic accidents, and they occurred in 1945 and 1946. The A.E.C. has reported that 69 persons have been accidentally injured by radiation. The total includes 28 affected by fallout following weapons tests.

The odds in favor of a major accident in a nuclear plant, according to A.E.C. Chairman Lewis L. Strauss, are only

one in 50 million. On the other hand, if such an accident did occur, the upper potential of damage would be 3,400 killed, 34,000 injured, and property damage up to $7 billion. In view of the magnitude of the possible loss, Congress last year made government insurance available to cover up to $500 million in claims for damage from a single nuclear accident.[19]

The A.E.C. in its latest semi-annual report, Jan. 31, 1958, listed 21 "incidents involving radiation" in the year 1956. Fourteen of the incidents resulted in some injury to personnel. Four of the incidents involved transportation accidents—two in which trucks overturned and dumped sealed containers of radioactive materials, and two train derailments including one in which a freight car containing uranium compound fell into a river. The truck and train accidents were stated to have caused no injuries. The following were among other incidents listed:

Milford, Conn.—Exposure of four men to radiation when a construction worker put a contaminated piece of string in his pocket and then in the glove compartment of his car.

Oak Ridge, Tenn.—Slight contamination of area near a laboratory from which radioactive dust was accidentally ejected.

Hanford, Wash.—Exposure of three workers to radiation from release of backed-up plutonium solution into control room.

Los Alamos, N. M.—Exposure of two employees to maximum permissible doses of radiation when contaminated blotting paper blew around room during an experiment.

Hanford, Wash.—Injury of operator when solution caused deterioration of protective rubber gloves.

Bayside, N. Y.—Death of one worker from non-radiation causes, and exposure of four others to radiation below permissible doses, as result of explosion.

An atomic accident which attracted wide attention occurred last October in England. An overheated reactor at the Windscale plutonium plant damaged chimney filters and caused showering of a 200-square-mile area with radioactive materials.

Problems in Disposal of Radioactive Wastes

One of the discomfiting aspects of atomic energy development is that much atomic waste cannot be disposed of in the usual manner but must be sealed and stored away until the radioactivity diminishes to the point of harmlessness—a matter of decades in many instances. Constant

[19] See Congressional Quarterly, *1957 Almanac*, p. 587.

piling up of this deadly material, however well removed from human contact, is a matter of concern. Much research has been put on the waste disposal question, but a satisfactory answer has not yet been found.

Radioactive wastes may be gaseous, liquid or solid. Gases are usually discharged through very tall stacks, often after filtration. In such cases the neighboring area is monitored for radioactivity. In some instances, even the milk of grazing cows must be checked for radioactivity.

Liquid wastes may consist of water used to cool some types of reactors or of wash water used in decontamination processes. The water may be retained in tanks until there is sufficient radioactive decay to permit its safe discharge into streams. In other cases, the waste water is allowed to soak into the ground or is piped out to sea. The A.E.C. has established several deep ground pits where it seems feasible to let liquid wastes seep into the earth.

High-level wastes, like the dangerous cesium-137 and strontium-90, which have an unusually long radioactive life, present the most serious disposal problem.[20] These wastes are stored in watertight, steel-lined concrete tanks and either buried deep in the earth or sunk to the bottom of the sea. The "burial grounds" established for them on land by the A.E.C. are fenced, closed to public access, and regularly checked.

Other methods of handling radioactive wastes, now under consideration, include extraction of the more dangerous elements for separate disposal, mixing and fusing of wastes with certain types of clay into insoluble blocks, and reduction of wastes to dry powder. A National Academy of Sciences-National Research Council report on Jan. 23, 1958, stated that the most promising method for the near future was disposal in salt deposits; abandoned salt mines or beds along the Great Lakes and the Gulf Coast might prove ideal burial grounds.

Controls to Reduce the Hazards of Radiation

Safety regulation of atomic energy centered originally in the A.E.C., but public health agencies have been taking on more responsibility in that regard since private industry

[20] According to a National Academy of Sciences report on Jan. 23, wastes containing cesium-137 and strontium-90 cannot safely "come in contact with any living thing . . . for 600 years."

entered the field.[21] A.E.C. still exercises considerable control through its power to license atomic energy producers and users and to inspect their facilities. The Joint Federal-State Action Committee, established after the Governors Conference last June, recommended to President Eisenhower on Dec. 5 that federal and state governments take various steps to promote cooperation and uniformity in the development and enforcement of health and safety codes relating to radiation hazards. An important move in that direction will get under way in mid-March when a national advisory committee, appointed by the U.S. Public Health Service, will meet to map radiation safety and control programs.

A number of the states have been studying the problem of radiation control, and some of them have initiated control programs. Ohio's state health department reported recently on the program which it instituted nearly a decade ago. Representatives of the department visited all industrial and educational institutions in the state known to possess X-ray equipment and inspected it for safety. Approximately 700 shoe-fitting fluoroscopes, some without exposure-limiting timers and all subjecting customers and clerks to needless radiation, also were found. The department's powers over medical use of X-rays, however, were largely advisory rather than regulatory; even continued use of the shoe-fitting machines was left up to local authorities. A program of monitoring waterways for radioactivity was initiated in Ohio in 1953. Weekly sampling of the air for radioactivity was begun a year later, chiefly to establish a base-line of natural activity in the atmosphere for purposes of comparison when atomic facilities are installed.[22]

New York State's sanitary code since Jan. 1 has forbidden the operation by unlicensed persons of X-ray and other equipment giving off radiation. The new rule is designed particularly to get rid of shoe-fitting X-ray machines and the so-called "spinograph" equipment sometimes used by chiropractors. A New York City board of health regulation, effective Feb. 15, restricts purchase of X-ray and fluoroscope equipment, and its use on human beings,

[21] All safety regulations rest primarily on standards for safe maximum radiation doses set by the National Committee on Radiation Protection and Measurements. Handbooks put out by this group, which was formed 30 years ago as an advisory committee to the Bureau of Standards, are basic texts for radiation exposure control.

[22] Ohio Department of Health, *Ohio's Health* (March 1957), pp. 13ff.

to doctors, dentists, osteopaths, podiatrists, and their authorized agents. Licenses for shoe-fitting machines are being withdrawn.

Basic to the safe use of X-ray equipment are the skill and care of the operator, the efficiency of the machine, and the taking of rather simple precautionary measures to shield the body from unnecessary radiation. Improvement in this connection is believed to be coming from the concern over radiation poisoning within the medical profession. Attention of doctors is being drawn in particular to the need to limit X-raying of children and pregnant women to a minimum. When the American Roentgen Ray Society, oldest of the scientific radiological organizations, met in Washington, D. C., last October, it declared war on needless or careless X-raying and on operation of X-ray equipment by inadequately trained persons.